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THE ECOLOGY OF *AGRIMONIA INCISA* TORREY & A. GRAY (ROSACEAE) IN THE WEST GULF COASTAL PLAIN

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ABSTRACT

The ecology of *Agrimonia incisa*, incised groovebur, in east Texas is described. It can be abundant in open pine forest. It is probably not widespread today because of widespread habitat alteration resulting from fire suppression during the twentieth century.

KEY WORDS: *Agrimonia incisa* Torrey & A. Gray, Texas, Rosaceae, Angelina National Forest

INTRODUCTION

Little is known about the biology and ecology of *Agrimonia incisa* (Kral 1983; Robbins & Hardin 1987; Orzell 1990; Grace 1993; Singhurst 1996; G. Kline, pers. comm.). Until recently, its known distribution was the lower coastal plain from South Carolina to Florida, westward to Mississippi (Radford, *et al.* 1968; Orzell 1990; Singhurst 1996; Kline, pers. comm.). In 1989 a disjunct population was reported from Angelina National Forest, Jasper County, Texas, about 500 km west of the closest known Mississippi site (Mahler 1989).

In 1993 and 1994 Singhurst (1996) reported *Agrimonia incisa* for eleven sites in Jasper, Angelina, Newton, and Sabine counties. Beginning in 1995, we have conducted extensive surveys for *A. incisa* around the original known locations on the Angelina National Forest. We have identified a distribution area approximately 11 km × 4 km straddling the Jasper-Angelina county line south of the Sam Rayburn Reservoir centering on 31° 04′ N 94° 11′ W. Within this area the species is now known from over 50 sites, many of which have dense populations. Outside this area, we have searched for it in likely habitat on the Angelina National Forest (*e.g.*, north of

the Sam Rayburn Reservoir and especially along the area to the west, including Boykin Springs and Upland Island Wilderness, which has similar soils) but have failed to locate it.

Outside the National Forest, we have found *Agrimonia incisa* at three locations in northern Newton County along State Highway R255, about 32, 34, and 51 km east of the Angelina National Forest sites, and Singhurst (1996) has reported it for one location about 6 km east of the Sam Rayburn dam in Jasper County.

Singhurst (1996) reports it for two sites on the Sabine National Forest: one in southern Sabine County and one in northern Newton County. Also, recent herbarium searches have turned up specimens from Anderson County, Texas, 19 km northwest of Palestine near Sand Lake. This site is approximately 185 km northwest of the Angelina National Forest populations. A search of the Anderson County area on July 24, 1996, failed to discover *Agrimonia incisa* and reconfirm this important range extension of the species. The species is not listed as part of the flora of Engeling Wildlife Management Area just north of Sand Lake (Telfair, *et al.* n.d.).

GENERAL DESCRIPTION AND BIOLOGY

Agrimonia incisa is one of seven North American species in the genus (Kline, pers. comm.). Technical descriptions of it and its congeners can be found in several sources (Kral 1983; Robbins & Hardin 1987; Orzell 1990; Singhurst 1996). Four species of *Agrimonia* are known for Texas, three of which occur in the southeastern part of the state: *A. incisa, A. microcarpa* Wallr., and *A. rostellata* Wallr., (Correll & Johnston 1970; Johnston 1990; Nixon & Kell 1993; Kline, pers. comm.). *Agrimonia incisa* is the most distinctive: its mid-stem leaves with nine short, coarsely incised major leaflets (mid-stem terminal leaflet less than 3 cm long, usually with eight deep incisions or nine teeth) identify it immediately. Although it is not frequently illustrated, the line drawings in Rickett (1967:192) show the leaf pattern perfectly.

Agrimonia incisa is an easy plant to monitor because it can be located year round. It blooms from July to September and dies back in the fall. But before stems of the year die back, a new basal rosette appears from a bud adjacent to the old stem. Even the tall, dry stems and withered leaves of old plants persist long into the following year.

PLANT ASSOCIATIONS

In east Texas, *Agrimonia incisa* favors sparse-canopied pine uplands and moderately open pine-oak associations and a rich herbaceous layer with few shrubs. Harcombe, *et al.* (1993) refer to similar habitat in the "Big Thicket" as "dry upland forests and savannas" and provide a good description (see also Marietta 1979; Ward 1984; Bridges & Orzell 1989).

To determine plant associations, we surveyed ten permanent $10m^2$ sites on three occasions (May 19, July 28, and October 3, 1996) and recorded all identifiable species present. The plot locations on the Angelina National Forest (Angelina and Jasper counties) were chosen for their abundance of *Agrimonia incisa* individuals and to give a representative geographic scatter over the Forest area occupied by the plants.

Species occurring in the sample plots are listed below according to relative frequency of occurrence, defined as presence in number of plots. Nomenclature mainly follows Kartesz (1994).

Occurred in ten plots: *Andropogon ternarius* Michx., *Centrosema virginianum* (L.) Benth., *Croton argyranthemus* Michx., *Dichanthelium aciculare* (Desv. *ex* Poir.) Gould & Clark, *Pityopsis graminifolia* (Michx.) Nutt., *Pinus palustris* P. Mill., *Toxicodendron radicans* (L.) Kuntze, and *Schizachyrium scoparium* (Michx.) Nash.

Occurred in nine plots: *Ambrosia artemisiifolia* L., *Aristida purpurascens* Poir., and *Tragia urens* L.

Occurred in eight plots: *Aristolochia reticulata* Jacq., *Berlandiera pumila* (Michx.) Nutt., *Gelsemium sempervirens* (L.) St. Hil., *Helianthus mollis* Lam., *Paspalum setaceum* Michx., *Rhus copallina* L., *Ruellia humilis* Nutt., *Sassafras albidum* (Nutt.) Nees, *Stillingia sylvatica* Garden *ex* L., and *Tragia urticifolia* Michx.

Occurred in seven plots: *Asimina parviflora* (Michx.) Dunal, *Callicarpa americana* L., *Gymnopogon ambiguus* (Michx.) B.S.P., *Hedyotis nigricans* (Lam.) Fosberg, *Paspalum plicatulum* Michx., and *Vernonia texana* (A. Gray) Small.

Occurred in six plots: *Euphorbia corollata* L., *Galactia regularis* (L.) B.S.P., *Gnaphalium obtusifolium* L., *Rhynchosia latifolia* Nutt. *ex* Torrey & A. Gray, *Rudbeckia hirta* L., *Stylosanthes biflora* (L.) B.S.P., and *Vitis aestivalis* Michx.

Occurred in five plots: *Croton michauxii* G.L. Webster, *Eragrostis spectabilis* (Pursh) Steud., *Glandularia canadensis* (L.) Nutt., *Digitaria cognata* (J.A. Schultes) Pilger, *Quercus incana* Bartr., *Quercus marilandica* Muenchh., *Rubus* sp., *Schrankia hystricina* (Small) Standl., and *Sporobolus junceus* (Beauv.) Kunth.

Occurred in four plots: *Aster patens* Ait., *Baptisia leucophaea* Nutt., *Ceanothus americanus* L., *Cornus florida* L., *Erigeron strigosus* Muhl. *ex* Willd., *Eriogonum longifolium* Nutt., *Helianthemum carolinianum* (Walt.) Michx., *Hymenopappus artemisiaefolius* DC., *Hypericum hypericoides* (L.) Crantz, *Ilex vomitoria* Ait., *Lechea mucronata* Raf., *Liatris elegans* (Walt.) Michx., *Pinus taeda* L., *Pteridium aquilinum* (L.) Kuhn, *Scutellaria elliptica* Muhl., *Stylodon carneus* (Medic.) Moldenke, and *Tradescantia reverchonii* Bush.

Occurred in three plots: *Alophia drummondii* (Graham) R.C. Foster, *Carya alba* (L.) Nutt. *ex* Ell., *Chrysopsis pilosa* Nutt., *Cnidoscolus texanus* (Muell.-Arg.) Small, *Echinacea pallida* (Nutt.) Nutt., *Lobelia puberula* Michx., *Physalis mollis* Nutt., *Quercus stellata* Wangenh., *Rhynchospora globularis* (Chapman) Small, *R. grayi* Kunth, *Tephrosia virginiana* Pers., and *Tragia smallii* Shinners.

Occurred in two plots: *Aristida lanosa* Muhl. *ex* Ell., *Asclepias amplexicaulis* Sm., *Aster sericeus* Vent., *Croptilon divaricatum* (Nutt.) Raf., *Crotalaria sagittalis* L., *Erythrina herbacea* L., *Hypericum gentianoides* (L.) B.S.P., *Lobelia appendiculata* A. DC., *Liquidambar styraciflua* L., *Lithospermum caroliniense* (Walt. *ex* Gmel.) MacM., *Matelea cynanchoides* (Engelm.) Woods., *Penstemon australis* subsp. *laxiflorus* (Pennell) Bennett, *Physalis heterophylla* Nees, *Pinus echinata* P. Mill., *Pediomelum hypogaeum* (Nutt. *ex* Torr. & A. Gray) Rydb. var. *subulatum* (Bush) J. Grimes, *Scleria ciliata* Michx., and *Trichostema setaceum* Houtt.

Occurred in one plot: *Acer rubrum* L., *Agalinis pulchella* Pennell, *Aster linearifolius* L., *Carex complanata* Torr. & Hook., *Conyza canadensis* (L.) Cronq., *Dichanthelium laxiflorum* (Lam.) Gould, *Digitaria villosa* (Walt.) Pers., *Gaillardia aestivalis* (Walt.) H. Rock., *Helianthus angustifolius* L., *Hieraceum gronovii* L., *Nothoscordum bivalve* (L.) Britt., *Passiflora lutea* L., *Persea borbonia* (L.) Spreng., *Polypremum procumbens* L., *Salvia azurea* Michx. *ex* Lam., *Solidago odora* Ait., *Tephrosia onobrychoides* Nutt., *Trichostema dichotomum* L., *Ulmus alata* Michx., *Vaccinium arboreum* Marsh., *Vaccinium stamineum* L., and *Vitis rotundifolia* Michx.

In the study plots we identified 111 species. The number of species per plot ranged from 37 to 53 (mean = 46, SD = 4.5). Asteraceae dominated (19%), followed by Poaceae (12%), Fabaceae (10%), and Euphorbiaceae (7%).

The plant frequencies listed above are fairly typical of West Gulf Coastal Plain upland longleaf pine savanna. The sub-community in which *Agrimonia incisa* occurs most resembles upland longleaf pine savanna subtype 1 (Bridges & Orzell 1989; Harcombe, *et al.* 1993), but there are some important differences. The plants listed for subtype 1 in Bridges & Orzell (1989) and Harcombe, *et al.* (1993) clearly inhabit more xeric sites than those in which *A. incisa* usually occurs. For instance, subtype plants *Aureolaria pectinata* (Nutt.) Penn., *Bulbostylis ciliatifolia* (El..) Fern., *Dalea* spp., and *Scutellaria cardiophylla* Engelm. & A. Gray, characteristically species of xeric habitats, are absent from our sample plots; these species favor sandhills (MacRoberts & MacRoberts 1996).

Our observations suggest that *Agrimonia incisa* favors a slightly more mesic habitat than described by Bridges & Orzell (1989) and Harcombe, *et al.* (1993) for subtype 1, and that the upland longleaf pine community favored by *A. incisa* falls slightly to the left (see their Tables 1 and 3) of the subtype 1 community. Orzell's (1990:23) description of *A. incisa* as occurring on "well-drained but not xeric, sandy soils" agrees more closely with our observations (see also Orzell 1990:408-416).

The herbaceous associates for *Agrimonia incisa* in the East Gulf Coastal Plain are much the same as those described for the West Gulf Coastal Plain (Kral 1983), except that they indicate a slightly more xeric habitat in the east.

Reports always associate *Agrimonia incisa* with longleaf pine, which makes the Anderson County location particularly interesting since it is outside the range of longleaf pine and perhaps the distribution of pine altogether. Unfortunately, we were unable to relocate the Anderson County population, but the general community in which it was found is oak-sandylands with many of the species characteristic of upland longleaf pine savanna. The Newton County sites are in loblolly and slash pine plantations that were probably longleaf pine prior to this century.

LIGHT CONDITIONS

In order to gather some quantitative information on the light conditions favored by *Agrimonia incisa*, we gathered data on canopy and shrub cover.

In twelve study plots in Angelina, Newton, and Jasper counties we estimated canopy cover. This ranged from 20% to 55% and averaged 35%. *Agrimonia incisa* gets direct sun part of the day, but is not directly exposed most of the day. At the same time, it favors bright indirect light.

Along a pine savanna/shrub edge, we examined the distribution of individual plants in relation to cover. Shrubs were *Callicarpa americana, Liquidambar styraciflua, Ilex vomitoria, Persea borbonia, Asimina parviflora, Cornus florida* L., and *Rhus copallinum*. We examined the two meter edge, dividing it into three parts: open (normal 35% canopy), edge (some direct sun, but shaded most of the time), shade (always shaded). Along this edge we located 75 plants: 50 plants (67%) were in the open, 22 plants (29%) were at the edge, and 3 plants (4%) were in shade. Of the three plants that we found in the shade, two appeared to be in poor condition--leggy and chlorotic.

Using a Weston light meter, we measured light conditions of *Agrimonia incisa* under normal conditions at noon. In one study plot with 35% canopy, the Weston measure was 19/20 in direct sunlight; in shade, it was 16/17; that is, in shade the light is about one quarter to one third that measured in direct sunlight.

These findings confirm our general impression that *Agrimonia incisa* prefers open woodlands and disappears as light levels decrease, avoiding deep shade altogether.

We have never encountered *Agrimonia incisa* in closed canopy forest nor in any area with a dense midstory or shrub layer; even a dense cover of *Pteridium aquilinum* appears to be inhospitable to it. On the other hand, we have never located it in open areas with no shade.

SOILS

In the study area, *Agrimonia incisa* occurs on sands on undulating to hilly, gently sloping uplands that are well drained, moderately permeable, and which quickly dry during drought.

We found it on three soil types: (LTC) Letney-Tehran association, (DUB) Doucette-Boykin association, and (LeC) Letney loamy sands, which are classified as loamy, siliceous, thermic Arenic (Plinthic, Grossarenic) Paleudults. Apparently, LTC and LeC are the same or very similar (Dolezel, *et al.* 1988; Neitsch, *et al.* 1982). These soils are found in northern Jasper and Newton counties, southern Sabine

County, and southeastern Angelina County. *Agrimonia incisa*, therefore, should be expected to occur in western Louisiana where the same plant/soil association occurs.

We took soil samples from the upper 15 centimeters for five populations of *Agrimonia incisa* in three counties (Table 1). Samples were from the three soil types described above. Analysis was done by A & L Analytical Laboratories, Memphis, Tennessee.

The soils where *Agrimonia incisa* occurs are acidic and nutrient poor.

Table 1. Soil characteristics of *Agrimonia incisa* sites.

		Exchangeable Ions (ppm)				
Sample	pH	P	K	Ca	Mg	OM%
Angelina 13	5.7	8	26	110	15	1.6
Angelina 14	5.7	14	23	280	44	4.9
Jasper 1	5.3	7	25	70	13	1.8
Jasper 9	5.4	7	27	120	22	2.9
Newton 2	5.8	12	29	190	26	3.3

POPULATION

In September 1995, we set up ten 5.5m^2 permanent plots for plant monitoring. These sites were selected because they contained large numbers of *Agrimonia incisa* and had not been burned for some years. All were open, with typical canopy and little or no shrub layer. In September 1995 and 1996, we counted the number of separate plants (stems) in each (Table 2). There was no radical disturbance in any of the plots in the two successive years, *i.e.*, none was burned, lumbered, etc.

It is evident from these figures that, while numbers fluctuated within plots (for which we have no explanation), there was no overall change between the two successive years for the total sample. Although such a small sample is of minimal interest, populations that have not burned for some years clearly are holding.

In order to obtain information on population numbers and plant distribution, in 1996 we ran five transects (all were 3 m wide, but were 0.5, 0.9, 1.0, 1.0, and 1.2 km long) through upland longleaf areas with *Agrimonia incisa*. The shortest transect was in Newton County; the other four were in Jasper County. These allowed us to estimate, at least for favorable habitat, plant densities. The estimates for each of the five transects are 503, 507, 730, 1400, and 1843 plants per ha.

Table 2. Number of plants in ten plots during two successive years.

Plot	Number of Plants		% Change
	1995	1996	
1	33	34	+3
2	55	36	-35
3	52	51	-2
4	91	101	+11
5	55	58	+5
6	41	46	+12
7	37	48	+30
8	14	23	+64
9	26	32	+23
10	63	45	-29
Total	467	474	+1

From our unquantified survey observations, we suspected that plant distribution was clumped. This was confirmed by the high density-to-frequency ratio found for all transects. In the 4.6 km transect (the five transects combined), we located 88 places with plants. These occupied 493 meters (11%) of the total and averaged 5.6 m (range 1 to 37 m). The average number of plants per clump was 16.7 (range 1-200).

In 1.9 km of transect, we measured not only the area occupied by plants, but also the distance between clumps. In the 0.9 km transect, the average distance between clump sites was 55 m (range 3-170 m) and in the 1.0 km transect, the average distance between clump sites was 31 m (range 4-135 m).

At only four places of the 88 in the five transects where *Agrimonia incisa* was found was there only one plant.

Put simply, if one plant is found, the probability is high that more (often many more) will be found within a few meters of it.

FLOWERING

In Texas, *Agrimonia incisa* flowers and produces fruit from mid-July through mid-September. This pattern appears to characterize other populations in the southeast (Robbins & Hardin 1987; Grace 1993).

The inflorescence is a spikelike raceme, sometimes branched, bearing numerous alternately arranged flowers. Flowers open in succession up the raceme, at such intervals that only a few are open together. Fruit is top-shaped, with several rows of bristles spreading from the middle, and readily attaches to passers-by and adheres to hair, shoelaces, and clothing (for a technical description see Kral 1983; Robbins & Hardin 1987; Orzell 1990).

To gather information on *Agrimonia incisa* flowering pattern and pollinators, on 7, 8, and 18 August 1996, we made continuous observations and periodic checks on the status of flowers in the field and captured insect pollinators. The *A. incisa* population used for these observations was about halfway through flowering. In this population, we marked specific plants and flowers and monitored them throughout the day.

We also made continuous observations on two greenhouse plants from 15 August to 7 September. Since the greenhouse observations were almost identical with those we made in the field, but involve a larger number of flowers, and were made after we had determined the basic outline of the flowering pattern, we will describe these observations in detail after giving the basic outline of flowering in the field.

For this description we use local time (CDT): sunrise on 7 and 8 August was about 6:40 am and sunset was about 8:10 pm. On 30 August (the middle of the greenhouse observations), sunrise was 6:50 am and sunset was 7:42 pm. The greenhouse observations were made in Shreveport, Louisiana, 160 km north of where the plants grow naturally. The field observations were made in northern Jasper County on clear sunny days; a few short, late afternoon thunder showers occurred on 7 August. During the greenhouse observations, there was one wet, rainy, overcast period. On all days it was hot and humid.

The flowering behavior of *Agrimonia incisa* is relatively simple. Each flower lasts for two days and opens twice: the petals open the first time at about 1:00 pm--then close at about 9:00 pm for the night; the flower opens for the second time the next day at about noon, and the petals begin dropping at about 4:30 pm. Consequently, on any given day there are two classes of flowers: those that originally opened the previous day, and new flowers of the day. Stems have individuals of both classes at any given time, the older flowers generally being below the newer on the raceme since buds open successively up the raceme.

Flowering: Field Observations

Flowers begin opening just after noon. These flowers are those that first opened the previous day. They take about 30 minutes to open and stay open until about 4:00 pm at which time they begin dropping their petals, which are all dropped by 5:30 pm. Of the 30 flowers we marked at 6:00 pm on August 7, all reopened on 8 August between 12:15 pm and 12:45 pm.

Slightly later (at about 12:30 pm), new flowers begin opening and continue opening until about 4:00 pm, with most opening during the first two hours (12:30 pm and 2:30 pm). Flowers open rapidly: each takes less than half an hour to open. They remain open until between 9:00 pm and 10:00 pm and remain closed until mid-day the next day, at which time they follow the pattern described above. The anthers of

flowers-of-the-day do not fully introrse until late in the afternoon, beginning about 7:00 pm. When these flowers open the next day, their anthers remain introrsed.

To gather information on the percentage of stems flowering, we selected five widely separated areas where *Agrimonia incisa* occurs in typical habitat on the Angelina National Forest. We walked transects counting all plants within the transect and noting whether it had flowered or not (had a raceme with fruit or not). Table 3 summarizes these data.

Table 3. *Agrimonia incisa* stems with raceme and fruit.

Sample site	Plant with raceme and fruit	Plant without raceme or fruit
1	63 (32%)	132 (68%)
3	54 (27%	133 (73%)
4	63 (39%)	100 (61%)
6	53 (38%)	87 (62%)
13	98 (44%)	127 (56%)
Total	331 (36%)	590 (64%)

Of 921 plants in the five transects, 36% had flowered and had fruit and 64% lacked racemes. The flowering plants were almost invariably larger than those that did not flower. Those that did not flower may be plants of the year germinated from last years' seeds or from tubers. In the first growing season, *Agrimonia* spp. produce only a short, few-leaved plant. Leaves rarely have more than three leaflets. In the second year, they develop leaves typical of the species and flower (Kline, pers comm.).

Flowering: Greenhouse

Flowering sequence and duration of greenhouse plants was the same as for field flowers. We made observations on two plants.

Plant 1 first bloomed on 15 August and had its final flower on 7 September. It had two racemes and 64 flowers. Plant 2 first bloomed on 30 August and was followed only until 4 September--about the first quarter of its blooming period. It had six flowers during this period.

On clear days, flowers that had first opened the previous day re-opened on average at 11:45 am (range = 11:00 am to 1:00 pm, sample size = 67) and began dropping their

petals at 4:00 pm (range = 3:00 pm to 5:00 pm, sample size = 57 flowers). Of 55 flowers, the total time open was 4.1 hours (range 3-5 hours).

On overcast days, flowers opened at 1:15 pm (range = 11:00 am to 3:00 pm, sample size = 15) and began dropping their petals at 7:00 pm (range = 4:00 pm to 10:00 pm, sample size = 19). Time open on overcast days averaged 6.6 hours (range 5.5-7.5 hours, sample size = 19). Thus, not only is timing delayed but the duration of opening is extended on overcast days.

On clear days, flowers-of-the-day opened on average at 1:15 pm (range = 1:00 pm to 2:00 pm. sample size = 66 flowers) and closed at 9:30 pm (range = 8:30 to 10:30 pm, sample size = 66 flowers). On overcast days, they opened at 3:30 pm (range = 2:00 pm to 6:00 pm, sample size = 29) and closed at 11:00 pm (range 8:30 pm to 12:00 pm, sample size = 23). Of 85 flowers, the total time open was 8.25 hours (range = 6-10 hours). There was no difference between clear or cloudy days: on cloudy days the timing of opening and closing is simply delayed about two hours.

Flowers-of-the-day and flowers of the previous day are easily distinguished. Those of the day are bright yellow and wide open, with petals and stamens at right angles to the ovary, and do not introrse until late afternoon or early evening. Anthers are bright yellow. Petals of previous-day flowers are dull yellow, with stamens fully introrsed, filaments twisted or arched, anthers against the stigma. Anthers are brown. Pollination will usually occur the first day a flower is open (Kline, pers. comm.). *Agrimonia* species are self-compatible; if they do not outcross, they will self-pollinate when the anthers introrse (Kline, pers. comm.).

Each stem has 1 to 9 flowers open at a time. On the thirteen plants we marked in the field and followed on 7 and 8 August, we found 48 flowers on the first day and 51 on the second, averaging 3.8 (range 1-9, SD = 1.7) flowers per plant per day, half of which were old and half new. This means that on average each plant has about two new flowers per day.

The greenhouse plants were slightly different because the main plant had two racemes. This plant had about 5.3 (range 1-9, SD = 2.4) flowers each day, half of which were new and half old.

POLLINATORS

Captured pollinators were small bees of the subfamily Halictinae (Hymenoptera, Apoidea, Halictidae), all probably the same species.

On sunny days, the bees were active between about 1:00 pm and 4:00 pm. We saw none after 4:00 pm, most activity being immediately after the flowers opened. They visited both flowers-of-the-day and those of the previous day. We did not make field observations on overcast and rainy days, so do not know how insect visits might have differed on those occasions. No insects were observed on the greenhouse plants, although the plants were not enclosed.

FRUIT

Agrimonia incisa, like all *Agrimonia* species, produces large, barbed fruit designed for long-range dispersal (although many, perhaps most, probably simply drop near the parent stem [Kline, pers. comm.]). We can add no information on seed dispersal, except to say that in late summer and fall, our pants and shoelaces were often covered with *Agrimonia* fruit, attesting to the effectiveness of their barbs. If we stooped over an *Agrimonia* patch, the mature fruit easily caught in our hair.

ROOTS

Agrimonia incisa has fusiform thickened tuberous roots and rhizomes. The tubers measure about 2.25(1.5-3.0) cm long and 3.2(2.0-5.0) mm wide (n =10). To determine if these might play any part in reproduction and in the clumped nature of *A. incisa* distribution, we collected several plants, cut off the tubers, and planted ten in a pot with soils taken from the collection site. The tubers were collected on 20 May and planted on 21 May 1996. On 16 July 1996, four sprouted; by 22 July, five had sprouted. The remaining five did not sprout. The five sprouts survived and produced a typical leafy rosette.

About half of all North American *Agrimonia* species have tuberous roots. In addition to *A. incisa, A. microcarpa, A. pubescens* Wallr., and *A. rostellata* have such roots (Kline, pers. comm.). Since little is known about the ecology of any of these species, it is hard to tell what the function of tubers might be, except to suggest that all of these species might occur in fire-dependent or droughty areas where food reserves or the alternative of clonal reproduction might be important. Certainly, *A. incisa* is such a species, and from what little we know about *A. microcarpa*, it too might experience frequent fire or short periods of drought

FIRE

All discussions of *Agrimonia incisa* management include statements about fire because the plant is associated with the longleaf system, which is clearly pyrogenic (Harcombe, *et al.* 1993; Platt, *et al.* 1988).

However, little is known about the effects of fire (or its seasonality, intensity, or timing) on the herbs and shrubs of any plant community in the southeastern United States (Robbins & Myers 1992; Grace 1993; Streng, *et al.* 1993). Certainly nothing has been published on *Agrimonia incisa* and fire (Singhurst 1996). The consensus appears to be that these upland pine systems burned regularly (every 1 to 3 years) and that they burned in the growing season.

While not extensive, we have made some observations relevant to this issue. In late February 1997, two of our 5.5m^2 study plots (numbers 7 and 8, Table 2) burned. On 24 March 1997, we counted the number of *Agrimonia incisa* rosettes in both. The numbers were 46 and 18, respectively. Clearly, in this small sample fire did not affect numbers. Within this same burn area was also one of our 10m^2 plots (see section "Plant Associations"). While we had not counted *Agrimonia* stems in this plot, we knew their distribution; their numbers seemed to have been unaffected by the fire.

We have not seen the effects of spring or summer fire on *Agrimonia incisa* and cannot say how plants might be affected by a "growing season" burn. But it is not unlikely that a similar pattern to that observed for this early burn would be found.

DISCUSSION

Agrimonia incisa is rare. It is on all state rare lists where it occurs and is considered threatened by the U.S. Forest Service. It is described as "very local and rarely encountered throughout its range" (Orzell 1990; see also Kral 1983).

Studying the populations in the Angelina National Forest, it is hard to imagine that this species is rare; that is, until it is realized that its habitat, open longleaf pineland, is a very rare community indeed. The biggest mystery is why the species in the West Gulf Coastal Plain is rather contained geographically on the Angelina National Forest, with apparently similar habitat existing along the Catahoula formation eastward into Louisiana and farther westward in Texas.

Reproductively, *Agrimonia incisa* appears to be stable in the study populations. It produces many fruits obviously adapted to long-range dispersal. When a shrub layer grows up, it is capable of surviving along the forested edge of roadsides, the edges of powerline rights-of-way, and pipelines. Most certainly, it is not a weedy species, but because of anthropogenic activity, it often only survives in refugia where its needs are met: areas that mimic the open savanna conditions once created by fire.

On the Angelina National Forest, the species is by no means confined to such refugia: it occurs in open savanna longleaf pinelands. Where we have found it in Newton County, it is also away from the roads in open slash and loblolly pine plantations.

MANAGEMENT

The populations of *Agrimonia incisa* on the National Forests and Grasslands in Texas are the only populations on public land in Texas or in the West Gulf Coastal Plain, which makes them readily accessible and potentially secure.

The major consideration for *Agrimonia incisa* management is how to maintain the integrity of the canopy and the herbaceous layer to promote proper light and shade levels. A dense canopy, shrub layer, and heavy rough are very likely detrimental to *A. incisa* development and maintenance. Traditionally, fire probably maintained open habitat, killing woody invaders and reducing ground litter. In the absence of fire, these conditions probably can be maintained by thinning the canopy to desired levels, bush-hogging shrubs, and mowing the grass layer. This procedure might be expensive for large tracts, but might work well for small populations.

But we know next to nothing about the one thing -- fire, as it interacts with *Agrimonia incisa* -- about which we should be informed best in order to manage this species. Thus, until the interaction of seasonal fire and *Agrimonia* is studied, little definitive can be said about management.

As regards other management factors, clearly excessive ground disturbance and herbicides should be avoided (see Kral 1983; Robbins & Hardin 1987; Orzell 1990; Singhurst 1996 for further comments on management).

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APPENDIX

Agrimonia incisa has been reported from Alabama, Florida, Georgia, Mississippi, South Carolina, and North Carolina (Texas Natural Heritage Program 1995). Apparently, the North Carolina report is an unverified site report (Jame Amoroso, pers. comm.; Kline, pers. comm.). It has been reported also for Angelina, Jasper, Newton, and Sabine counties in Texas (Singhurst 1996). Nixon & Sniffen collected *A. incisa* in Anderson County twenty-five years ago but misidentified it as *A. parviflora*. We looked in what appeared to be suitable habitat (Anderson County is outside the pine belt) in the location indicated on their herbarium label, but were unable to relocate it. Below are vouchers for Texas counties. We have not seen a voucher for Sabine County although Singhurst (1996) reports it from that county.

Anderson Co.: *Nixon & Sniffen 3840* [ASTC]. Angelina Co.: *MacRoberts & MacRoberts 3007, 3113* [ASTC], *3006* [LSUS], *3115* [DEK]. Jasper Co.: *MacRoberts & MacRoberts 2886, 2896, 2898, 2900, 2910, 2929* [ASTC], *2899*

[BRCH], *2861, 2897* [LSUS], *3121, 3289* [DEK]. Newton Co.: *MacRoberts & MacRoberts 3120* [ASTC], *3117* [LSUS], *3119* [DEK].

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